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RESTRICTED CIRCULATION

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EFFECT OF WINTER ENVIRONMENT ON THE GROWTH OF YOUNG BEEF CATTLE - C V SMITH

1. INTRODUCTION

This note was undertaken at the request of the Livestock Environment Specialist of ADAS.

Its purpose is to examine in greater detail the work reported by McCarrick and Drennan (1972) in 'Animal Production'.

Trials, over 3 winters in Eire, were carried out to compare the performance of 9 month-old Friesian Steers, of around 200 kg body weight, kept in the 3 environments provided by

(a) a conventional (roofed) but fairly open cattle house

(b) wind sheltered, roofless sawdust pads (not cubicles in these experiments)

(c) unsheltered, roofless sawdust pads. Within each environment, the animals were fed at 2 levels (hay, and hay plus supplementary barley).

The conclusion quoted is:-
'No interaction on live-weight was found between plane of nutrition and winter environment'.

One must be careful not to take this statement out of context and bear in mind that 'winter environment' here refers to those associated with the 3 types of shelter.

The lack of response to shelter demonstrated in Experiments 1 and 3 (though not in Experiment 2 for animals fed a low plane) need not surprise us too greatly.

We know that for housed cattle to thrive, the ventilation of the building must be good and so the temperature lift within the building small - at most a few degrees. In this instance we are dealing with a narrow (lean to) building with an opening around 3 sides of 1.5 metres between the side walls and the eaves. The air temperature contrast between any of the 3 environments provided will have been small. Likewise the radiant temperature contrast will have been small without a deliberately insulated roof.

The animals, kept in groups, would by their social behaviour provide a mutual and not insignificant shelter from the wind, even without the presence of 'solid' vertical sheeting around the site or the shelter provided by hay stacks.

The main differences between the indoor and outdoor environments will have been in the periodic wetting of the outdoor animals by rain; even so, some acclimatisation (increase in coat length of the outdoor animals over those housed indoors) was observed. This would have gone some way to mitigate the effects of rain.

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Among the data reported by McCarrick and Drennan are graphed daily values of observations appropriate to an agro-meteorological station and graphed periodic live-weight gains (which are interpreted by this reader as the weight gains between successive weighings and not from the beginning of the experiment).

It is apparent that for the animals on a low plane of nutrition, and particularly so in Experiment 2 that the weight of the animals may go up or down over the periods (approximately 2 weeks) between weighings - see Figure attached.

It is of interest to consider a question not raised by McCarrick and Drennan, namely the response of weight gain to environment, where environment now is closely specified by the day-to-day weather.

2. CRITICAL TEMPERATURE

The metabolic heat generated and dissipated by an animal is a function of

its size (age or weight)
its food intake (heat increment due to feed)
the 'quality' of the fodder (metabolisable energy/unit of feed)
its thermal environment (the heat loss by radiation, convection, etc)
its degree of insulation (from the thermal environment)

At the lower end of the comfort zone, the environmental temperature below which the animal has to increase its heat production in order to prevent its body temperature from falling, is called its Critical Temperature. This Critical Temperature is specified in still air, or where, in effect, air movement arises primarily from convection currents initiated by the animal.

If we change the level of feeding, we change the Critical Temperature. Below the Critical Temperature, the animal must produce more heat to keep itself warm. Primarily this is achieved by an increase in the catabolism of fat (almost certainly from body reserves).

The Critical Temperature estimated by Blaxter (1962) for steers

fed at maintenance	is $7^{\circ}C$
gaining 500g/day	is $-1^{\circ}C$

3. THE DATA

Daily values of maximum and minimum air temperatures were obtained from punched card data from the experimental site, The Agricultural Institute, Dunsany, County Meath. Where observations were missed, they were supplemented by those from Birr Castle in central Eire. Wind data were not reported on the punched cards and the wind speeds reported at 1200 GMT daily from Birr Castle were used in the study that follows. (This standard wind observation is likely to be an over-estimate of the air movement experienced by the animals).

We concern ourselves with the animals fed at the lower level (hay alone) and note that hay intakes were controlled (at the level of the intake of the group with the lowest appetite) and that the hay was of 'medium to low quality'.

4. TEMPERATURE CONSIDERATIONS

EXPERIMENT 1 - WINTER OF 1966/67

The graphs of McCarrick and Drennan show that to all intents and purposes, over the period covered by the 2 weighings after the beginning of the trial (about 42 days), the animals were being fed at a maintenance level (zero weight gain).

The average daily mean air temperature ($\frac{1}{2}$ maximum + $\frac{1}{2}$ minimum) on the site over this period was 5.3°C.

The Critical Temperature for the age and class of stock being studied, probably fed to appetite on medium to poor quality hay is thus set at 5.3°C.

This figure is now used as a predictor of performance over the subsequent experiments.

EXPERIMENT 2 - WINTER OF 1967/68

In Tables 2a and 2b we show the mean air temperature over the intervals between 2 successive weighings (roughly 15-20 days) and also for the running periods covered by 3 successive weighings (roughly 30-40 days). In addition we show the sign of the observed weight change over these intervals.

Table 2a

Time from beginning of experiment	Time between weighings	Assigned Critical Temperature	Mean Air Temperature	Observed weight gain	Expected weight gain
0-15 days	15 days	5.3°C	6.3°C	+	+
16-40	25	5.3	4.8	-	-
41-53	13	5.3	2.5	-	-
54-70	17	5.3	7.0	+	+
71-88	18	5.3	3.2	-	-
89-103	15	5.3	2.3	-	-
104-129	26	5.3	6.1	+	+

Table 2b

Time from beginning of experiment	Time between weighings	Assigned Critical Temperature	Mean Air Temperature	Observed weight gain	Expected weight gain
0-40 days	40 days	5.3°C	5 0	+	(-)
16-53	38	5.3	3.3	-	-
41-70	30	5.3	5.0	+*	(-)
54-88	35	5.3	4.9	+	(-)
71-103	33	5.3	2.8	-	--
89-129	41	5.3	4.7	-	-

* indicates estimated value due to missing data
( ) indicates a discrepancy between observed and expected weight gains

EXPERIMENT 3 - WINTER OF 1968/69

In Tables 3a and 3b we show similar data to those set out in Tables 2a and 2b.

Table 3a

Time from beginning of experiment	Time between weighings	Assigned Critical Temperature	Mean air temperature	Observed weight gain	Expected weight gain
0-12 days	12 days	5.3°C	8.6°C	+	+
13-28	16	5.3	5.0	+	(-)
29-42	14	5.3	2.5	0	(-)
43-56	14	5.3	3.5	-	-
57-69	13	5.3	6.7	+	+
70-84	15	5.3	2.0	0	(-)
85-110	26	5.3	1.4	+	(-)
111-140	30	5.3	5.5	+	+

Table 3b

Time from beginning of experiment	Time between weighings	Assigned Critical Temperature	Mean Air Temperature	Observed weight gain	Expected weight gain
0-28 days	28 days	5.3°C	6.5	+	+
13-40	30	5.3	3.7	+	(-)
29-54	28	5.3	3.8	+	(-)
43-66	27	5.3	5.0	0	(-)
57-82	28	5.3	4.0	+	(-)
70-110	41	5.3	1.6	+	(-)
85-140	56	5.3	3.6	+	(-)

It would appear that whilst temperature alone is often a useful predictor of weight change, it does not, of itself provide a necessary and sufficient criteria to anticipate such changes.

5. TEMPERATURE AND AIR MOVEMENT CONSIDERATIONS

If the airflow over an animal is increased, its (forced) convective heat loss is increased. For models (of animals) of simple shape, for example, cylinders, it may be shown that the convective heat loss is proportional to some power (0.5 or 0.6) of the air velocity. The transfer of this kind of information back to the problems of heat loss posed by live animals, particularly when the coat is not windproof, is not simple. Nevertheless, such calculations enable one to suggest an order of magnitude (perhaps not more than 1°-2°C) for the decrease in Critical Temperature of steers fed at a maintenance leve, when the imposed air movement falls from 10 kt to 'still air' conditions.

The mean wind speed (at mid-day) over the period of Experiment 1 was 11.9 kt. We note, as before that the mean air temperature was 5.3°C and that these animals were being fed at a maintenance level.

The observed wind speeds over the periods between weighings of Experiments 2 and 3 were generally in the range 5-8 kt. Because of these lower wind speeds we assign a difference of 0.5°C to the value of the Critical Temperature previously adopted, and now re-examine the data set down in the earlier tables. Tables 2c, 2d, 3c and 3d take an assigned Critical Temperature of 4.8°C as appropriate.

Table 2c

Time from beginning of experiment	Time between weighings	Mean air velocity	Assigned Critical Temperature	Mean air temperature	Observed weight gain	Expected weight gain
0-15 days	15 days	5.3 kt	4.8°C	6.3°C	+	+
16-40	25	8.0	4.8	4.8	-	(0)
41-53	13	6.9	4.8	2.5	-	-
54-70	17	8.0	4.8	7.0	+	+
71-88	18	5.4	4.8	3.2	-	-
89-103	15	5.7	4.8	2.3	-	-
104-129	26	11.9	4.8	6.1	+	+

Table 2d

Time from beginning of experiment	Time between weighings	Mean air velocity	Assigned Critical Temperature	Mean air temperature	Observed weight gain	Expected weight gain
0-40 days	40 days	7.0 kt	4.8°C	5.0°C	+	+
16-53	38	7.6	4.8	3.3	-	-
41-70	30	7.5	4.8	5.0	+	+
54-88	35	6.6	4.8	4.9	+	+
71-103	33	5.6	4.8	2.8	-	-
89-129	41	9.6	4.8	4.7	-	-

Table 3c

Time from beginning of experiment	Time between weighings	Mean air velocity	Assigned Critical Temperature	Mean air temperature	Ovserved weight gain	Expected weight gain
0-12 days	12 days	8.2 kt	4.8°C	8.6°C	+	+
13-28	16	6.8	4.8	5.0	+	+
29-42	14	6.3	4.8	2.5	0	(-)
43-56	14	5.0	4.8	3.5	-	-
57-69	13	8.0	4.8	6.7	+	+
70-84	15	5.7	4.8	2.0	0	(-)
85-110	26	6.0	4.8	1.4	+	(-)
111-140	30	6.8	4.8	5.5	+	+

Table 3d

Time from beginning of experiment	Time between weighings	Mean air velocity	Assigned Critical Temperature	Mean air temperature	Observed weight gain	Expected weight gain
0-28 days	28 days	7.4kt	4.8°C	6.5°C	+	+
13-40	30	6.5	4.8	3.7	+	(-)
29-54	28	5.7	4.8	3.8	+	(-)
43-66	27	6.5	4.8	5.0	0	(+)
57-82	28	6.8	4.8	4.0	+	(-)
70-110	41	5.9	4.8	1.6	+	(-)
85-140	56	6.7	4.8	3.6	+	(-)

We note now that Experiment 2 (Tables 2c and 2d) shows an excellent agreement between Observed and Expected weight gain. Experiment 3 evidently still requires further consideration.

One obvious comment is that over days 29-82 of Experiment 3, the reported weight changes are marginal. We have concerned ourselves only with the sign and not the magnitude of the reported weight gain. There are well known difficulties and probable errors associated with the body weight measurement of animals of large body (gut) volume. The changes of sign of weight gain over the period of days 29-82 of Experiment 3, are possibly within the limits of error of the measurement. However no great stress is placed on this point.

A second more relevant comment is that there are apparent internal inconsistencies between the meteorological data and the observed body weight changes of Experiment 3, if the Critical Temperature (essentially an energy balance approach) is considered a useful and valid parameter. For example, in Table 3c, mean air temperature of 2.0°C and 2.5°C are associated with zero weight gain, a mean air temperature of 1.4°C is associated with a body weight increase, a mean air temperature of 3.5°C is associated with a fall in body weight.

Before suggesting that the anlaysis carried out so far is now faulted, it is as well to realise that the environmental data only give us information about one side of the enimals energy balance (the environmental demand or heat loss). So far little or nothing has been said about the other side of the equation and the energy intake of the animals.

The information given by McCarrick and Drennan on food is simply the average dry matter intake over the complete periods of each experiment. There is no break down over the intervals between weighing. More importantly, no direct information is given (in absolute or relative terms) of the metabolisable energy per unit of feed supplied over the 3 winters. All that we have are Dry Matter, Nitrogen, Calcium, Phosphorous, Potassium and Magnesium percentages. We can perhaps infer from the fodder analyses and food intake reported, that the quality (and energy) of the feed in Experiment 3 was rather better than in either Experiment 1 or 2 (Nitrogen 1.91% as against 1.67% and 1.62%; Dry Matter intake 4.77kg/day as against 4.36 and 4.18 kg/day.

We now assign a lower Critical Temperature than 4.8°C to the data of Experiment 3 (because of the better quality feed compared with Experiment 1). Proceeding down in steps of 0.5°C we find the first reasonable overall fit is given by a Critical Temperature of 3.3°C.

The results with such a Critical Temperature are shown in Tables 3e and 3f. The inconsistencies noted earlier are still with us

Table 3e

Time from beginning of experiment	Time between weighings	Mean air velocity	Assigned Critical Temperature	Mean air temperature	Observed weight gain	Expected weight gain
0-12 days	12 day	8.2 kt	3.3°C	8.6°C	+	+
13-28	16	6.8	3.3	5.0	+	+
29-42	14	6.3	3.3	2.5	0	(-)
43-56	14	5.0	3.3	3.5	-	(+)
57-69	13	8.0	3.3	6.7	+	+
70-84	15	5.7	3.3	2.0	0	(-)
85-110	26	6.0	3.3	1.4	+	(-)
111-140	20	6.8	3.3	5.5	+	+

Table 3f

Time from beginning of experiment	Time between weighings	Mean air velocity	Assigned Critical Temperature	Mean Air temperature	Observed weight gain	Expected weight gain
0-28 days	28 days	7.4 kt	3.3°C	6.5°C	+	+
13-40	30	6.5	3.3	3.7	+	+
29-54	28	5.7	3.3	3.8	+	+
43-66	27	6.5	3.3	5.0	0	(+)
57-82	28	6.8	3.3	4.0	+	+
70-110	41	5.9	3.3	1.6	+	(-)
85-140	56	6.7	3.3	3.6	+	+

6. CONCLUSIONS AND COMMENTS

(1) McCarrick and Drennan were primarily concerned with the effects of 'housing' and their data show that the animals performed equally well (or badly) in each of the shelters provided.

Meteorological data was conscientiously collected and reported, but no analysis was attempted.

(2) There is more to be got from the data than the authors realise, or are prepared to acknowledge.

Provided by 'winter environment' we imply the thermal environment and not simply the presence or otherwise of particular types of shelter, then on the data reported it is possible to reverse the conclusion of McCarrick and Drennan and to state that, 'It is possible to demonstrate an interaction between liveweight gain, winter environment and plane of nutrition.'

(3) If the thermal environment in winter in effect provides air temperatures, around or below the Critical Temperatures for the class of stock, then body weights will at best be only maintained during such cold spells.

(4) For the class of stock investigated, viz 9 month old steers at around 200 kg, fed to appetite on poor to medium quality hay, the Critical Temperature (at wind speeds of 8–12 kt) appears to be of the order $4.8^{\circ} - 5.3^{\circ}C$ ($40.5^{\circ} - 41.5^{\circ}F$).

With better quality hay this Critical Temperature appears to be nearer $3.3^{\circ}C$ ($38^{\circ}F$) and may be as low as $2^{\circ}C$ ($35.5^{\circ}F$).

(5) Areas in the UK where such temperatures are commonly experienced in the winter half of the year will be set out in a later memorandum (Ag Mem 474).

(6) It is suggested that the authors would probably have benefited from the general recommendations set down in the WMO Technical Note - 'Meteorological Observations in Animal Experiments'.

7. REFERENCES

McCarrick R B Drennan M J	1972	Effect of winter environment on growth of young beef cattle. Anim Prod 14: 97–105.
Blaxter K L	1962	The energy metabolism of ruminants Hutchinson, London.
Smith C V (Editor	1970	Meteorological observations in animal experiments. Technical Note No. 107. World Meteorological Organisation, Geneva.

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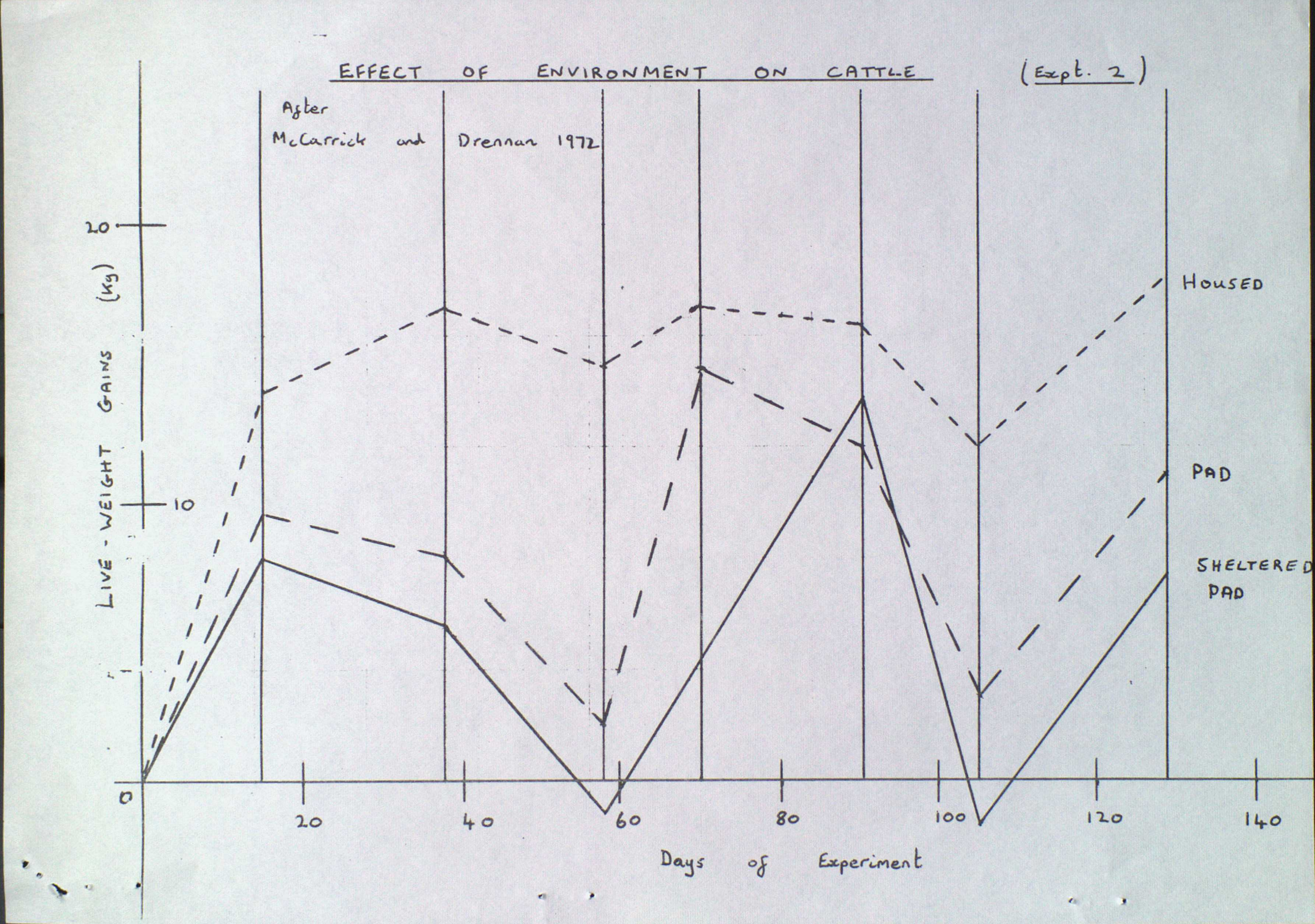
EFFECT OF ENVIRONMENT ON CATTLE (Expt. 2)
After McCarrick and Drennan 1972
LIVE-WEIGHT GAINS (kg)
20
10
0
20
40
60
80
100
120
140
Days of Experiment
HOUSED
PAD
SHELTERED PAD